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Harnessing solar energy for sustainable energy management in the campus: case study of Juet, Guna

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ABSTRACT

The proliferation of institutes and universities of higher learning in the country and the imperative need for the reduction in energy consumption is critical for the development of a sustainable campus. Such centralized organizations along with their dense populations constituting young students and experts from various specializations serve as ideal sites for application of sustainable

development principles. These principles integrate the technical knowledge of all specializations to increase the efficiency of built infrastructure and promote conservation practices thereby reducing environmental impacts. The study area discussed in this paper is Jaypee University of Engineering & Technology (JUET), housing more than 2500 students inside its campus spread over an expanse of 125 acres off the Agra-Bombay national highway in Guna district, M.P. The study area has most favourable conditions like larger number of sunny days and higher day temperatures (above 30^0 C) for most part of the year. The present work discusses about the existing scenario of energy utilization in campus and the options for harnessing solar energy as a replacement in a view of enhancing energy conservation. The areas of application considered in this paper are water heating, water pumping, outdoor lighting and cooking using solar photovoltaic modules and concentric collectors. The paper also discusses about the options and areas for optimization of energy utilization in the campus through energy efficient devices. Development of such management plan provides both economical savings and ecological benefits. The results suggested that the study area has a good potential for harnessing solar energy, which could result in considerable savings on energy expenditure in the long run.

Keywords: solar energy, energy management, sustainable campus and photo voltaic modules.

1. INTRODUCTION

The last decade has witnessed a growing public awareness regarding sustainability. Role of higher educational institutions is predominant in the society due to their increasing number of institutes and students joining them. Article 19 of the Stockholm Declaration of 1972, mentions the need to promote environmental education from the youngest age possible. This conference followed by declarations such as Tbilisi Talloires and Swansea have highlighted the importance of sustainable development in educational institutions through education, research and application. A sustainable campus promotes the resource efficiency (water and energy) in campus and demonstrates the importance of environmental conservation and pollution control; to the students through better sitting, design, construction, operation, operation and maintenance (Eric 2012; Patel and Patel 2011; Habib and Ismaila, 2008). Particularly in Indian scenario inculcating concept of sustainability among the young citizens through educational institutions is highly relevant due concerns like increasing population, urbanization and industrialization.

Energy sector has been one of major area of concern, due to the increasing energy consumption. India's energy mix is mostly dominated by thermal power using coal. With increasing concerns globally due to increased emissions causing global warming, policy makers are forced to search for alternative energy sources to meet their energy demands. Hence sustainable energy generation has been gaining its prominence day by day. Renewable resources such as solar energy, wind energy, biomass energy, geothermal energy, tidal energy and geothermal energy are feasible options for replacement of conventional energy resources (Garg, 2012; Kamkan et al., 2011). Solar energy has a significant role in the replacement for India, as global solar radiation incident over India ranges from 1200 to 2300 kWh/m^2/year with about 300 clear sunny days (Pillai and Banerjee, 2009; Sudhakar and Srivastava, 2012; Ramachandra et al., 2011; Saeed and Sharma, 2012; Azucena et al., 2014).

The utilization of solar energy has been increasing due to its applications for water heating, cooking, street lightning and conversion to either heat or electricity. Particularly the market for photo voltaic modules has been increasing in the recent times due to its feasibility in electricity conversion. Solar energy conversion takes place through solar cell, a number of solar cells connected together form a pv module. PV modules can be either either stands alone, grid connected or hybrid systems. Inverters are required for converting direct current to alternating current. The performance of PV modules are rated according to operating temperature of 25 ^oC, spectral distribution of AM 1.5 and an incident solar irradiance of 100 W/m^2. Hence harnessing natural resources like solar and wind are the most feasible options to satisfy the growing demands. The present work discusses about the options for sustainable energy generation through solar energy utilization (Zeman, 2015).

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1.2. Study Area

The study area discussed in the paper is, Jaypee University of Engineering & Technology (JUET), established by Jaiprakash Sewa Sansthan (JSS) located in Raghogarh, along the Agra-Mumbai national highway, Guna district, M.P. The university is spread over an expanse of 125 acres, housing a population more than 3500 inside its campus. Presently the university has been offering various courses at graduate, post graduate and doctoral level in the field of engineering and sciences**.** The layout of campus is shown in figure 1. The university has well designed buildings with natural ventilation and greater area of plant cover, following some eco-friendly principles like reuse of domestic waste water in gardening, collecting the rain water of the campus in lake for domestic reuse, imparting environmental education through tours and courses. But however with the growing population in the university these facilities have been insufficient to cater to the estimated needs; hence there is a need to develop a modified approach for conservation and proper utilization of resources available in the campus.

1.2.1. Options for energy efficiency in campus

- University has a separate substation; hence incorporation of devices such as solar photo voltaic modules (PV) for electricity generation can be directly connected to the grid.
- Utilizing the PV modules over roof top area connected to grid, off grid options such as street lightning, water heating and pumping provides both economic and ecological benefits.
- Buildings in the university were well designed following the green principles provides lesser dependence on energy for heating, ventilation and air conditioning, in addition to the above replacement of existing fixtures with energy efficient devices enhances the scenario.
- The region where the university exists was identified as potential area by Madhya Pradesh Trade and Investment Facilitation Corporation, for solar power generation with radiation upto 6.2 kWh/sqm/day and 300 days of clear sun (MPTRIFAC, 2014).
- The university is situated along highway away from town; hence interference in solar radiation is minimum, so maximum benefits can be derived through harnessing the solar energy.

2. METHODOLOGY

The temperature data was collected on daily basis (hourly data) obtained from Environtech wind monitor (WM 271) existing in the environmental engineering laboratory of campus. The data was collected throughout the year, to estimate the number of sunny days. The numbers of sunny days were estimated on the basis of number of days in the year having temperature 25 ^{o}C for a constant period of time. After a thorough analysis of temperature data an average value of 6 hours (above temperature 25 ^{o}C) in 300 sunny days has been considered for further calculations in estimating the potential. The methodology is in assessment of the potential from each building. The power consumption pattern and electricity bill data was obtained from the substation in the campus. The PV module considered in study was polycrystalline manufactured by Moser Baer India. The peak power output of the module is 230 Wp. The dimensions of each module are 1*1.7 m, with a spacing of 1.4 m provided to prevent shading between modules and to facilitate easy movement. The module configuration was selected from case study in IIT Roorkee campus (AHEC, 2015). Losses of 30 % were considered due to conversion and other factors (Solanki, 2008). The utilizable roof top area was estimated through inspection of the roof top areas of buildings and available area for providing pv modules was estimated after deducting area used for fixtures such as water tanks, pipes, air cooling chambers etc.

Figure 1 Layout of the campus

3. RESULTS AND DISCUSSIONS

3.1. Temperature Variation

Figure 2 shows the diurnal variations in temperature for all the months. Particularly the day temperatures are quite favourable throughout the year, for productive utilization. From the figure it can be understood that April, May and June have temperatures above 40^{o}C, particularly 8-9 hours per day above 25 ^{o}C. During rest of year also favourable temperature exists for effective utilization of solar radiation. In colder months starting from November to February and for certain duration during rainy season potential was observed to be quite minimum.

3.2. Potential Areas of Application

Table 1 shows the available roof top area, number of pv modules that can be provided and total power generation potential for each building (per day considering duration of 6 hours for 300 days). The generated power in the hostels (for boys and girls) can be utilized for water heating during winter and for air cooling during the summer. During the rest of period it can be used for pumping the water. In case of residential areas (ATS 1,2,3 and bachelor accommodation), shopping area, academic buidings (1,2 &3) and school building can be directly connected to grid for running appliances. Food is cooked commonly for both boys and girls (designated as Annapurna mess), mechanized cooking is adopted, hence power generated can be used for cooking and cleaning. Multipurpose hall (or auditorium) has been utilized as indoor stadium on daily basis, hence generated power can be used for lightning the area.

The energy generated in the academic block can be effectively utilized for computer systems in the case of AB-1 that supports 5 computer labs with a cumulative of 285 systems and 24 air conditioners with each of these labs functioning for 3-4 hours per day. In case of AB-2, generated power can be used in the lecture theatres and other class rooms functioning during working hours. Library (commonly called as learning and resource centre) is a part of the third AB- 3, it spreads over three floors and has 28 air conditioners and 30 computer systems in the digital section, generated power can be utilized here.

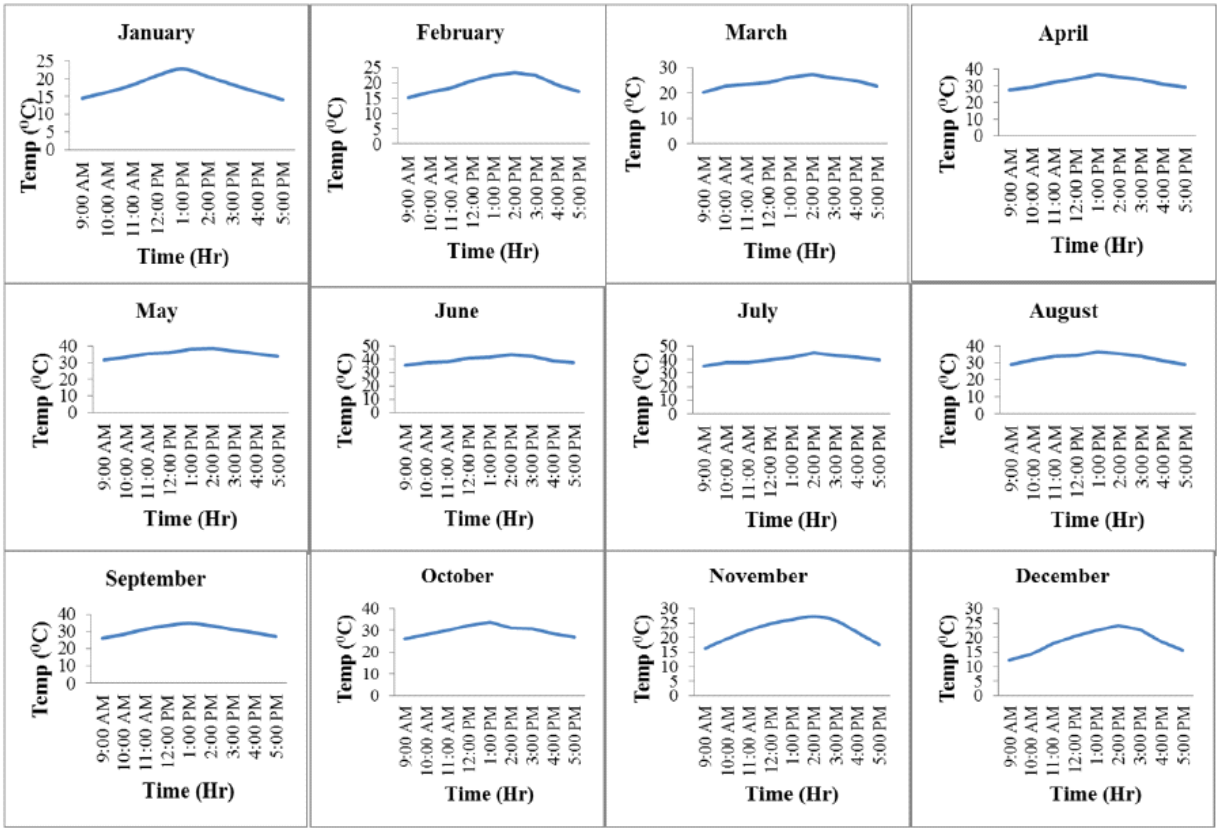

Figure 2 Diurnal daytime variations in temperature during various months

Table 1 Area statement and power generation potential

S.No.	Building	Available Roof top area (m^2)	Number of PV modules	Power units generated per day (KWh)
1	Academic Block			
	AB-1	5679	204	197.06
	AB-2	6593	969	936.05
	AB-3	5700	838	809.51
	AB extension	1586.15	233	225.08

2	Hostel			
	Boys:H1-H12	21848.9	2142	2069.17
	Boys:H14-H16	5618	550	531.3
	Boys:H17-H21	10400	1019	984.35
	Girls:GH-1	14665	1437	1388.14
	Girls:GH-2	16190	1587	1533.04
	School Hostel	8500	833	804.68
3	Accommodation			
	ATS1(A to H)	11748.56	1151	1112.64
	ATS2(H toE)	4909	481	464.65
	ATS3(F to HE)	2400	235	227.01
	Bachelor Accommodation	1045	102	98.53
4	Annapurna Mess	8795.22	1293.4	1249.4
5	Multi Purpose Hall	5000	612	591.2
6	School Building	5192	763	737.06
7	Tuckshops and cafe	2325	341	329.41

4. CONCLUSION

The paper discussed the potential of solar energy that can be harnessed for utilization in different buildings through pv modules. In addition to the above replacement of existing electrical fixtures with energy saving devices, utilization of separate solar cookers, street lighting systems, water pumps etc will lead to the greater savings on the overall energy expenditure. With increasing bureau of energy efficiency certified manufacturers in the country, these areas offer greater potential in future. However these aspects were not considered in paper for implementation in future. Capital cost for installing the photo voltaic modules is high, but savings in long run will be substantial. Creating awareness among the students regarding the resource utilization and implementation of above discussed strategy, encourages the students to inculcate sustainable life style for conservation of planet.

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